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Use of ISO 717 low-frequency sound insulation descriptors in acoustic regulations and recommendations for housing in Europe

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Introduction

Most countries in Europe have acoustic regulations for housing, including airborne and impact sound insulation requirements between dwellings, expressed using ISO 717 descriptors. Almost all requirements apply the default frequency range starting from 100 Hz. However, in some of the Nordic countries low-frequency (LF) spectrum adaptation terms 50-80 Hz are included in the regulations and in others recommended.

In addition to regulations, national acoustic classification schemes for housing exist in more than ten countries in Europe. The schemes specify a number of quality classes, reflecting different levels of acoustic protection, and include class criteria concerning several acoustic performance areas like in regulations. For the airborne and impact sound insulation criteria in the classification schemes, all five Nordic countries as well as Lithuania and Austria use LF descriptors in the upper classes, but other countries do not.

When a high acoustic protection is requested by a builder, one of the upper classes could be recommended as design basis, and use of LF-descriptors or not will depend on which national acoustic classification scheme is referred to.

The paper summarizes the specific sound insulation descriptors applied in regulations and recommendations for housing, including the higher classes in acoustic classification schemes, where LF-descriptors are applied in several countries.

Sound insulation descriptors in ISO 717

In Europe, the ISO 717 sound insulation descriptors from [1] are applied in building regulations. An overview of descriptors intended for sound insulation between dwellings is found in Table 1. In [2-4] are found tables including descriptors mainly intended for external noise sources (like e.g. traffic).

Table 1: Overview ISO 717 descriptors for evaluation of sound insulation between rooms in buildings.

ISO 717:2013 descriptors for evaluation of field sound insulation	Airborne sound insulation between rooms (ISO 717-1)	Impact sound insulation between rooms (ISO 717-2))
Basic descriptors (single-number quantities)	R'_w $D_{n,w}$ $D_{nT,w}$	$L'_{n,w}$ $L'_{nT,w}$
Spectrum adaptation terms (listed according to intended main applications)	*None* C $C_{50\text{-}3150}$ $C_{100\text{-}5000}$ $C_{50\text{-}5000}$	*None* C_I $C_{I,50\text{-}2500}$
Total number of descriptors	3 x 5 = 15	2 x 3 = 6
Note: For simplicity, only 1/3 octave quantities and C-terms are included in the table, although some countries allow 1/1 octave measurements for field check.		

The LF-descriptors were introduced in ISO 717 in 1996. The history of sound insulation descriptors is explained in [4].

Sound insulation descriptors in regulations

Comparative studies of requirements in Europe for sound insulation between dwellings are described in [2-4], and limit values are found in [2] and [3]. − An updated number of countries applying various sound insulation descriptors is found in Table 2.

Table 2: Sound insulation descriptors applied for regulatory requirements between dwellings in 31 countries in Europe. Status February 2019. Update from [2].

Airborne sound		Impact sound	
No. of countries	Descriptor	No. of countries	Descriptor
15	R'_w	17	$L'_{n,w}$
7	$D_{nT,w}$	9	$L'_{nT,w}$
3	$R'_w + C$	2	$L'_{nT,w} + C_I$
3	$D_{nT,w} + C$	2	$L'_{nT,w} + C_{I,50\text{-}2500}$
1	$D_{nT,w} + C_{50\text{-}3150}$	1	L'_w
1	$D_{nT,A}$ ($\approx D_{nT,w} + C$)	?	Variants
1	$D_{nT,w} + C_{tr}$	?	Recommendations
?	Variants	?	Special rules
?	Recommendations		
?	Special rules		

Compared to [2], there seems to be a slow trend towards more countries applying descriptors based on $D_{nT,w}$ and $L'_{nT,w}$. Only two countries have LF-descriptors included in acoustic requirements for housing, namely Sweden − having applied spectrum adaptation terms down to 50 Hz for both airborne and impact sound insulation between dwellings since 1999 − and Finland, where an LF-requirement for impact sound was introduced in January 2018. However, in three other countries − Iceland, Norway and Lithuania – the regulations recommend (through reference to Class C, see Tables 4-6) to apply LF-descriptors down to 50 Hz for both airborne and impact sound insulation. In Denmark, the regulations recommend use of LF-descriptors for light-weight walls and floors, see summary in Table 7.

In England and Wales (having the same regulations), $D_{nT,w} + C_{tr}$ is applied as descriptor for airborne sound insulation between dwellings. The idea behind including C_{tr} for evaluation of sound insulation between dwellings was to take into account low frequencies without actually testing at low frequencies. However there are indications that this is not a balanced way to meet the needs for increased sound insulation at low frequencies, see discussion and related references in [4].

Since LF-descriptors were introduced in ISO 717 already in 1996, it could have been expected that more countries had introduced such descriptors in acoustic regulations. However, revising building regulations (with all related guidelines), adjusting building practices and administration could be very complex and thus a huge task.

Sound insulation descriptors in quality classes

Acoustic classification schemes (ACS) define a number of quality classes reflecting different levels of acoustic comfort and protection, se illustration in Table 3. The ACS are national and very different due to lack of coordination between countries.

Table 3: Range of acoustic quality classes using various, partly fictive ranges and denotations.

	Acoustic quality class						
☺ ☺ ☺ High acoustic protection and comfort	A	B	C	D	E	F	☹ ☹ ☹ Low acoustic protection and comfort
	III	II	I				
			a	b	c	d	
	A	B	C	D			

An overview of existing national acoustic classification schemes in Europe for dwellings, [5-17], is found in Table 4. For each scheme listed, the class denotations, number of classes and the relation to the national building code are indicated. Information about an international proposal is found in [18]. Table 4 also includes number of classes below and above the national regulations. The variety of airborne and impact sound insulation descriptors applied in the classification schemes for housing in Table 4 are found in Tables 5 and 6. Several differences between the national acoustic classification schemes are found, see details and conclusions described in e.g. [2]. – From Tables 5-6, it is seen that Germany [12-13] has no LF-descriptors in any classes and that the quite new Polish ACS [16] applies the descriptor $R'_w + C_{tr}$ in the two upper classes, i.e. a similar approach as for regulations in England and Wales.

The Norwegian classification scheme [8] is under revision, and the proposed descriptors in prNS 8175:2018 for class C, are $R'_w + C_{50\text{-}3150}$ and $L'_{n,w} + C_{I,50\text{-}2500}$, i.e. a potential strengthening from recommendation to requirement.

In the proposal for an international classification scheme for dwellings, see [18], LF-descriptors are applied in the two highest classes as also done in seven national schemes (see table 7). This decision was a compromise between different contradicting viewpoints.

In research, there seems to be an increased attention to LF-performance, and several journal and conference papers deal with the topic. As examples, see e.g. [23-26] from both European and overseas countries.

A majority of acoustic experts from several countries seem convinced about the necessity of considering LF in the evaluation, dependant on the situation, of course, but especially important for impact sound. In the new DIN 4109 Handbuch [27] about German regulations, the present descriptors for requirements (without LF) are discussed and questioned in Ch. 3, and the committee NA 005-55 FBR KOA 05 - Schallschutz has initiated an investigation of the relevance of LF in DIN 4109.

In several countries, contractors and major parts of the building industry have been very reluctant about LF-descriptors, but it seems as if time has come to a more open approach due to more knowledge about the needs and the construction solutions. For example, in a new book [28] about sound insulation in wooden buildings, LF data are included, although not required by the regulations in DIN 4109-1:2018.

Table 4: European schemes for acoustic classification of dwellings, [5-17], relation to building regulations and information about number of classes. ISO/FDIS 19488 (2018), [18], has been included for comparison.

Acoustic classification of dwellings - Schemes in Europe and relation to building codes – Status Feb. 2019								
Country	Year of publication	ACS Reference (latest version)	Class denotations(1)	BR link to CS	BR ref. to ACS & Comments	No. of classes	No. of classes > BR	No. of classes < BR
DK	2001 / 2007 / 2018	DS 490 (2018)	A / B / C / D / E / F	+	Class C	6	2	3
FI	2004	SFS 5907 (2004)	A / B / C / D	–	N/A (BR > Class C)	4	2	~ 1½
IS	2003 / 2011 / 2016	IST 45 (2016)	A / B / C / D	+	Class C	4	2	1
NO	1997 / 2005 / 2008 / 2012	NS 8175 (2012)	A / B / C / D	+	Class C	4	2	1
SE	1996 / 1998 / 2004 / 2015	SS 25267 (2015) (4)	A / B / C / D	–	N/A (Class C = BR (4))	4	2	1
LT	2003	STR 2.01.07 (2003)	A / B / C / D / E	+	Class C	5	2	2+npd
IT	2010	UNI 11367 (2010)	I / II / III / IV	–	N/A (BR ~ Class III	4	2	1
DE	1994 / 2007 / 2012	VDI 4100 (2012) (2)	III / II / I	–	N/A (BR < Class I (2))	3	~ 3	~ 0
DEGA(3)	2009 / 2018	DEGA Empfehlung 103 (2018) (3)	A*/ A / B / C / D / E / (F)	–	N/A (BR ~ Class D (3))	6+npd	4	1+npd
AT	2012	ÖNORM B 8115-5 (2012)	A / B / C / D / (E)	–	N/A (BR = Class C)	4+npd	2	1+npd
NL	1999	NEN 1070 (1999)	I / II / III / IV / V	–	N/A (BR ~ Class III)	5	2	2
PL	2017	PN-B-02151-5:2017 (4)	AQ-4 / AQ-3 / AQ-2 / AQ-1 / AQ-0	–	N/A (Class AQ-0 = BR (4))	5	4	0
TR	2017	Noise Protection and sound insulation in Buildings(5)	A / B / C / D / E / F	+	Class C	6	2	3
ISO/WI	ISO/WI 19488 since 2014	ISO/FDIS 19488 (Aug. 2018)	A / B / C / D / E / F and npd	N/A	N/A (See note(6))	6+npd	N/A	N/A

Abbreviations: BR = Building Regulations (regulatory requirements); ACS = Acoustic Classification Scheme

(1) Classes are indicated in descending order, i.e. the best class first. Denotations in brackets correspond to npd.

(2) The revised version of VDI 4100 published in 2012 changed descriptors from R'_w and $L'_{n,w}$ to $D_{nT,w}$ and L'_{nT} (as had been discussed for years for the regulations), and class criteria were made stricter, i.e. above and regulations. After tightening of DIN 4109-1 in 2016, the basic criteria for the lowest class I for MS-housing are again similar to regulations, but VDI 4100 has additional criteria, e.g. on internal sound insulation.

(3) In addition to VDI 4100, the German Society of Acoustics (DEGA) has published a recommendation, DEGA-Empfehlung 103, "Schallschutz im Wohnungsbau – Schallschutzausweiz". For MS-housing, Class D criteria in general correspond to regulations, but there are additional criteria.

(4) SS 25267 and PN-B-02151-5 do not include class C and AQ-0 criteria, respectively, but refer to values in the BR.

(5) "Noise Protection and Sound Insulation in Buildings" www.resmigazete.gov.tr/eskiler/2017/05/20170531-7.htm (May 2017).

(6) Original proposal prepared by COST TU0901 in 2013. ISO/WI 19488 from 2014, ISO/FDIS Aug. 2018 and same limits in ISO/NP TS 19488 Jan. 2019.

Table 5: Airborne sound insulation between dwellings. Descriptors in acoustic classification schemes in Europe. References [5-17]. ISO/FDIS 19488 (2018), [18], has been included for comparison.

Airborne sound insulation between dwellings - Descriptors for class (1) criteria – Status Feb. 2019							
Country (1)	**Class A NL, IT: I DE/PL: III /AQ-4**	**Class B NL, IT: II DE/PL: II /AQ-3**	**Class C NL, IT: III DE/PL: I /AQ-2**	**Class D NL, IT: IV PL: AQ-1**	**Class E NL: V PL: AQ-0**	**Class F**	**BR reference to ACS**
DK	$R'_w + C_{50-3150}$	$R'_w + C_{50-3150}$	R'_w	R'_w	R'_w	R'_w	Class C
FI	$R'_w + C_{50-3150}$	$R'_w + C_{50-3150}$	R'_w	R'_w	N/A	N/A	None (BR ~ Class C)
IS	$R'_w + C_{50-3150}$	$R'_w + C_{50-3150}$	R'_w (5)	R'_w	N/A	N/A	Class C
NO	$R'_w + C_{50-5000}$	$R'_w + C_{50-5000}$	R'_w (5)	R'_w	N/A	N/A	Class C
SE	$D_{nT,w} + C_{50-3150}$	$D_{nT,w} + C_{50-3150}$	$(D_{nT,w} + C_{50-3150})$	$D_{nT,w} + C$	N/A	N/A	None (Class C = BR)
LT	$R'_w + C_{50-3150}$ or $D_{nT,w} + C_{50-3150}$	$R'_w + C_{50-3150}$ or $D_{nT,w} + C_{50-3150}$	R'_w or $D_{nT,w}$ (5)	R'_w or $D_{nT,w}$	R'_w or $D_{nT,w}$	N/A	Class C
IT	R'_w	R'_w	R'_w	R'_w	N/A	N/A	None (BR ~ Class III)
DE (2)	$D_{nT,w}$	$D_{nT,w}$	$D_{nT,w}$	N/A	N/A	N/A	None (BR < Class I)
DEGA (3)	R'_w	R'_w	R'_w	R'_w	R'_w	npd	None (BR ~ Class D)
AT (4)	$D_{nT,w} + C_{50-3150}$	$D_{nT,w} + C_{50-3150}$	$D_{nT,w}$	$D_{nT,w}$	npd	N/A	None (BR = Class C)
NL	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	N/A	None (BR ~ Class III)
PL	$R'_w + C_{tr}$	$R'_w + C_{tr}$	$R'_w + C$	$R'_w + C$	$(R'_w + C)$	N/A	None (Class AQ-0 = BR)
TR	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	Class C
ISO/FDIS (6)	$D_{nT,w} + C_{50-3150}$	$D_{nT,w} + C_{50-3150}$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	$D_{nT,w} + C$	N/A

Abbreviations: BR = Building Regulations (regulatory requirements); ACS = Acoustic Classification Scheme. .
(1) For references to classification schemes, see separate information. Classes indicated in descending order, i.e. the best class first.
(2) The classification scheme VDI 4100 has separate class criteria for multi-storey and row housing, the latter being 9-10 dB stricter.
(3) In addition, there is another scheme, DEGA-Empfehlung 103 with 6 classes A*-E and class F = npd, descriptor R'_w applied. Due to lack of space in the table, Class A* is not included.
(4) For row housing, Class C has a special 5 dB stricter criterion to match the building regulations; the class is denoted $C_{R.}$
(5) Use of $C_{50-3150/5000}$ is recommended also in Class C. If applied, the limit value may be reduced, see references.
(6) The descriptors indicated are from ISO/FDIS 19488 (Aug. 2018), the same as in ISO/NP TS 19488 (Jan. 2019).

Table 6: Impact sound insulation between dwellings. Descriptors in acoustic classification schemes in Europe. References [5-17]. ISO/FDIS 19488 (2018), [18], has been included for comparison.

Impact sound insulation between dwellings – Descriptors for class (1) criteria - Status Feb. 2019							
Country (1)	**Class A NL, IT: I DE/PL: III /AQ-4**	**Class B NL, IT: II DE/PL: II /AQ-3**	**Class C NL, IT: III DE/PL: I /AQ-2**	**Class D NL, IT: IV PL: AQ-1**	**Class E NL: V PL: AQ-0**	**Class F**	**BR reference to ACS**
DK	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	Class C
FI	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ (5)	$L'_{n,w}$	N/A	N/A	None (BR > Class C)
IS	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ (5)	$L'_{n,w}$	N/A	N/A	Class C
NO	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ and $L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ (5)	$L'_{n,w}$	N/A	N/A	Class C
SE	$L'_{nT,w}$ and $L'_{nT,w} + C_{I,50-2500}$	$L'_{nT,w}$ and $L'_{nT,w} + C_{I,50-2500}$	$(L'_{nT,w}$ and $L'_{nT,w} + C_{I,50-2500})$	$L'_{nT,w}$	N/A	N/A	None (Class C = BR)
LT	$L'_{n,w} + C_{I,50-2500}$	$L'_{n,w} + C_{I,50-2500}$	$L'_{n,w}$ (5)	$L'_{n,w}$	$L'_{n,w}$	N/A	Class C
IT	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	N/A	N/A	None (BR ~ Class III)
DE (2)	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	N/A	N/A	N/A	None (BR ~ Class I)
DEGA (3)	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	npd	None (BR ~ Class D)
AT (4)	$L'_{nT,w}$, $L'_{nT,w} + C_I$ and $L'_{nT,w} + C_{I,50-2500}$	$L'_{nT,w}$ and $L'_{nT,w} + C_I$	$L'_{nT,w}$	$L'_{nT,w}$	npd	N/A	None (BR = Class C)
NL	$L'_{nT,w} + C_I$	$L'_{nT,w} + C_I$	$L'_{nT,w} + C_I$	$L'_{nT,w} + C_I$	$L'_{nT,w} + C_I$	N/A	None (BR ~ Class III)
PL	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	$L'_{n,w}$	N/A	None (Class AQ-0 =BR)
TR	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	Class C
ISO/FDIS (6)	$L'_{nT,w}$ and $L'_{nT,w} + C_{I,50-2500}$	$L'_{nT,w}$ and $L'_{nT,w} + C_{I,50-2500}$	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	$L'_{nT,w}$	N/A

Abbreviations: BR = Building Regulations (regulatory requirements); ACS = Acoustic Classification Scheme.
(1) For references to classification schemes, see separate information. Classes indicated in descending order, i.e. the best class first.
(2) The classification scheme VDI 4100 has separate class criteria for multi-storey and row housing, the latter being 5 dB stricter.
(3) In addition, there is another scheme, DEGA-Empfehlung 103 with 6 classes A*-E and class F = npd, descriptor $L'_{n,w}$ applied. Due to lack of space in the table, Class A* is not included.
(4) For row housing, Class C has a special 5 dB stricter criterion to match the building regulations; the class is denoted CR.
(5) Use of $C_{I,50-2500}$ is recommended also in Class C.
(6) The descriptors indicated are from ISO/FDIS 19488 (Aug. 2018), the same as in ISO/NP TS 19488 (Jan. 2019).

Summary and conclusions

A summary of findings from comparative studies in Europe of low-frequency sound insulation descriptors in acoustic regulations, recommendations and acoustic classification schemes is found in Table 7.

Table 7: Number of countries in Europe applying ISO 717 low-frequency sound insulation descriptors.

LF descriptors in acoustic regulations, recommendations and acoustic quality classes in Europe			
Number of countries	Acoustic regulations		Acoustic quality classes
	Mandatory	Recommended	
Airborne	1 (SE)	3 (IS, NO. LT) + 1 (1)	7 (2)
Impact	2 (SE & FI)	3 (IS, NO. LT) + 1 (1)	7 (2)
(1) In DK, it is recommended using LF-descriptors in case of light-weight constructions (walls < 100 kg/m^2, floors < 250 kg/m^2), [21].			
(2) Classes A and B in DK, FI, IS, NO, SE, AT: LF-descriptors included.			

Until now, only two countries have LF-descriptors included in acoustic requirements for housing: Sweden since 1999 and Finland since 2018 [22]. However, more countries have recommendations and several countries have LF-descriptors included in the acoustic quality classes stricter than regulations, cf. Table 5, 6 and 7. In addition, there seems to be increasing attention to and concern about the LF-performance, cf. e.g. the journal and conference papers [23-26] and recent literature related to acoustic regulations [27] and constructions [28].

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